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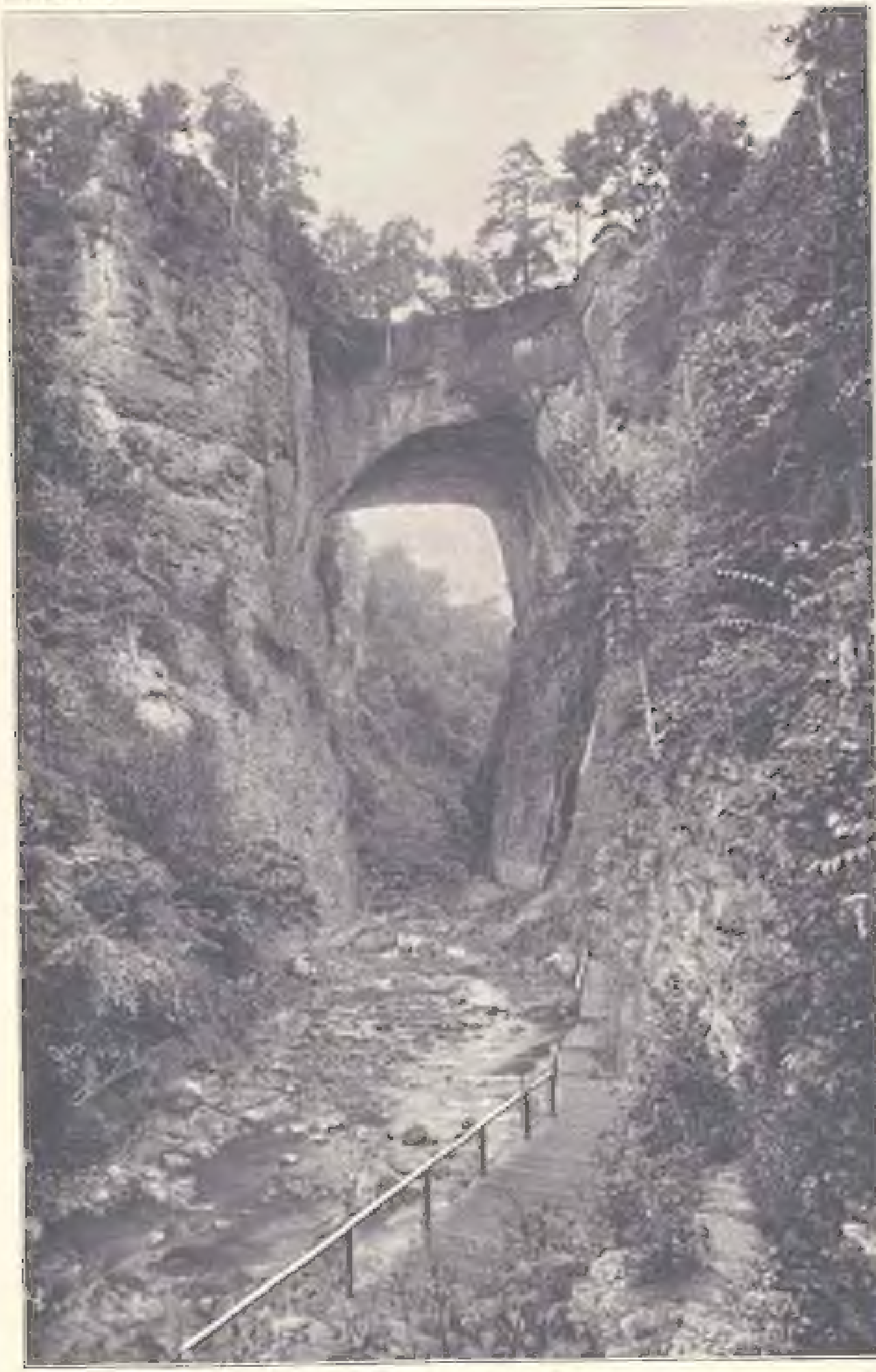

NATURAL BRIDGE, VIRGINIA.

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THE
NATIONAL GEOGRAPHIC MAGAZINE

THE NATURAL BRIDGE OF VIRGINIA

BY
CHARLES D. WALCOTT

The Natural Bridge of Virginia is one of those striking geographic features of America which, like Niagara falls and many other natural features, will in time disappear under the action of the agencies of erosion. The same forces that created will ultimately destroy them. In the case of Niagara, the rate of wear of the platform over which the water rushes has been measured, and the rate of retreat of the falls of the stream is known. Natural bridge is slowly but surely wearing away, and it appears to be desirable to record by photographic and notes the present condition of the bridge as a means of determining in the future the changes that occur from time to time. For this purpose a set of photographs, with notes taken in 1891, have been placed in the library of the United States Geological Survey.

The present article includes a few observations on the origin and the present condition of the bridge. The accompanying view (frontispiece plate 21) is one looking northward through the arch, and it accurately represents the condition of the bridge and canyon at the time it was taken. It may be that a more detailed description, with a full series of views, will be published in the future.

During the field season of 1891 I studied the rocks exposed along the channel of Cedar creek, a small tributary of the James river in Rockbridge county, Virginia. The first strata

rest with in growing up from the river are highly inclined limestones and shales of middle or upper Cambrian age. These are succeeded by the massive Knox dolomites, which are nearly vertical or inclined slightly westward. A few hundred feet below Natural bridge the westward dip decreases very rapidly, and at the bridge the beds are nearly horizontal, while a short distance above they are rising westward and dipping eastward toward the bridge at an angle of 5° to 10°. This increases to 20° to 25° higher up the stream.

A diagrammatic section of the rocks cut through in the canyon of Cedar creek gives the outline shown in figure 1. The bridge is at *A*, Lace falls at *B*, and James river at *C*. No attempt is made to show the depth of the canyon or gorge through which Cedar creek flows.

It is not supposed that the present Cedar creek began to erect its channel across the edges of the upturned beds from *B* to *C* when the present topographic features were established; on the contrary, it began its work long before, under conditions

FIGURE 1.—*Outline of strata at Natural Bridge.*

and in rocks that have since disappeared in the general erosion of the surrounding country. The course of the stream was determined by circumstances connected with the life history of James river. When the latter obtained a new lease of active life and lowered its channel through the Blue ridge, Cedar creek began to cut down its bed in the peneplain and to prepare the way for the possibility of the existence of an arch over its channel.

The general mode of formation has long been described for this and other natural rock bridges. In this case in detail it is considered to be as follows: Cedar creek was engaged for a considerable period in excavating the gorge from the James river to a point not far below the present site of the bridge, where a fall appears to have existed, the summit of which was not far if at all below the present level of the top of the bridge. About this time the water found a subterranean passage in the limestone farther up the stream than the present site of the bridge, and through this it flowed and discharged beneath the brink of the falls.

The passage gradually enlarged until all the waters of the creek passed through it and the bridge began its existence. What the length of this subterranean passage was is a matter of conjecture; it may have been one hundred or several hundred feet. All of its roof has disappeared except the narrow span of the bridge, and the abutting walls have been worn back by erosion until the gorge or canyon is much wider than at the bridge. The bridge is massive and strong, and the supporting walls rise in solid, almost unbroken, mural faces to the spring of the arch, nearly 200 feet above the bed of Cedar creek, as clearly shown in the accompanying plate (which is reproduced mechanically from a photograph taken by the author).

The position of the massive layers of limestone at the center of the low synclinal gives them power to resist erosion to a much greater extent than the upturned strata above and below the bridge. The condition of the latter favors rapid disintegration, and the result is shown in the widening of the gorge. The retreating lower level of the stream is now at Lace falls, nearly a mile above the bridge. The gorge below the bridge widens out more rapidly, owing partly to the erosion caused by a small brook that enters from the north, partly to the greater period of erosion to which it has been subjected.

On the northern side opposite Pulpit rock, about twenty feet west of the public road, the summit of the bridge is 200 feet above the water, and this part of the arch has a thickness of 41 feet and a span of from 45 to 60 feet. The western edge is about ten feet higher, and the eastern edge about ten feet lower than the central point.

The massive layers of limestone forming the bridge are gradually wearing away on the outer edges from the action of water and frost. If water-breaks were arranged so that the water could not flow in upon the bridge and about it from the southwestern side, and if a shed with water-tight roof were built over the arch, disintegration and destruction would be indefinitely postponed. As it is, it will be many centuries before the natural processes of erosion now at work upon and within the arch will completely break it down.

Since the preceding was written, an article has appeared in the *New York Tribune* of May 15, 1893, in which an account is given of the discovery of a passage in the limestone near Natural

bridge that extends from the plain above down to the stream below. It is described as follows:

"The passage was probably created by a stream of water finding a crevice in the limestone mountain, and by the gnawing of years the same cause that created the natural bridge. But it has all the appearance of design and purpose. A brief description by one who has recently been in the light of handkerchief candles shows at the entrance a room about twenty feet by ten, with a ceiling sixty feet in height, then a low, arched doorway into a room narrower than the former and extending forty or fifty feet up a steep flight of steps. The arches here are from fifteen to twenty feet in height, and their color a liquid blue. There are a few stalactites from the ceiling and many crystal forms on the wall. Passing here from a direct course through another arched doorway, beautifully decorated, about six feet in height, there is a round room, twenty feet in diameter and perhaps fifty feet from pit to dome. Out of the side of this passage a stone cascade, perfect as any waterfall, appears at the lower edge, about ten feet in length and eight in breadth. As the light is thrown upon this it has all the appearance of a living waterfall. A passage under this over a bridge leads to a labyrinth hardly wide enough for one to pass. The walls are about fifteen feet in height and the walls glisten like polished marble. These windings extend about thirty feet and open into a well-shaped room not at any point more fifteen feet in diameter and opening about thirty feet above, to the sky."

From the description it is evident that the passage was worn by percolating waters that found their way from the plain above to the lower level by the stream below, along some previously existing crevices. This process of erosion may be seen at the "Underground river" between Natural bridge and Lace falls, where a strong current of water flows through a channel in the limestone that is about ten feet above the level of Cedar creek and only exposed to view for a few feet of its length. All of the phenomena observed at Natural bridge and in the canyon of Cedar creek are repeated in many limestone regions. Sometimes they give rise to underground caverns, as at Mammoth cave, and more rarely to canyons and natural bridges. The illustration at the natural bridge is one of the finest known, and worthy of study by any one interested in geologic phenomena or the beautiful in nature.

THE GEOGRAPHICAL POSITION AND HEIGHT OF MOUNT SAINT ELIAS

BY

DR T. C. MENDENHALL

(*Presented before the Society April 28, 1885*)

In connection with the survey of the boundary line between Alaska and the British Northwest Territory it became necessary to determine the geographical position of mount Saint Elias.

Previous approximate determinations had shown that the peak of this mountain must be very near the 141st meridian, which constitutes the greater part of this boundary line, and that its distance from the seacoast must be very nearly ten marine leagues, which by treaty is to determine the position of the line in the absence of a range of mountains parallel to the windings of the coast.

It thus appeared that this peak is likely to prove of very great value as a corner-stone in this great boundary line, being at the junction of the 141st meridian and that part of the line which is so vaguely defined in the treaty.

The execution of the work in the immediate vicinity of the mountain was intrusted to assistants J. E. McGrath and J. Henry Turner, whose previous explorations and long residence in the interior of Alaska in connection with the determination of the 141st meridian are well known to the members of this Society.*

The complete reduction of the observations made has not yet been accomplished, but enough has been done to show the geographical position of the mountain peak within a very small error, and the Society will probably be interested in the preliminary results of this work, which are not likely to be modified sensibly by the completed calculations.

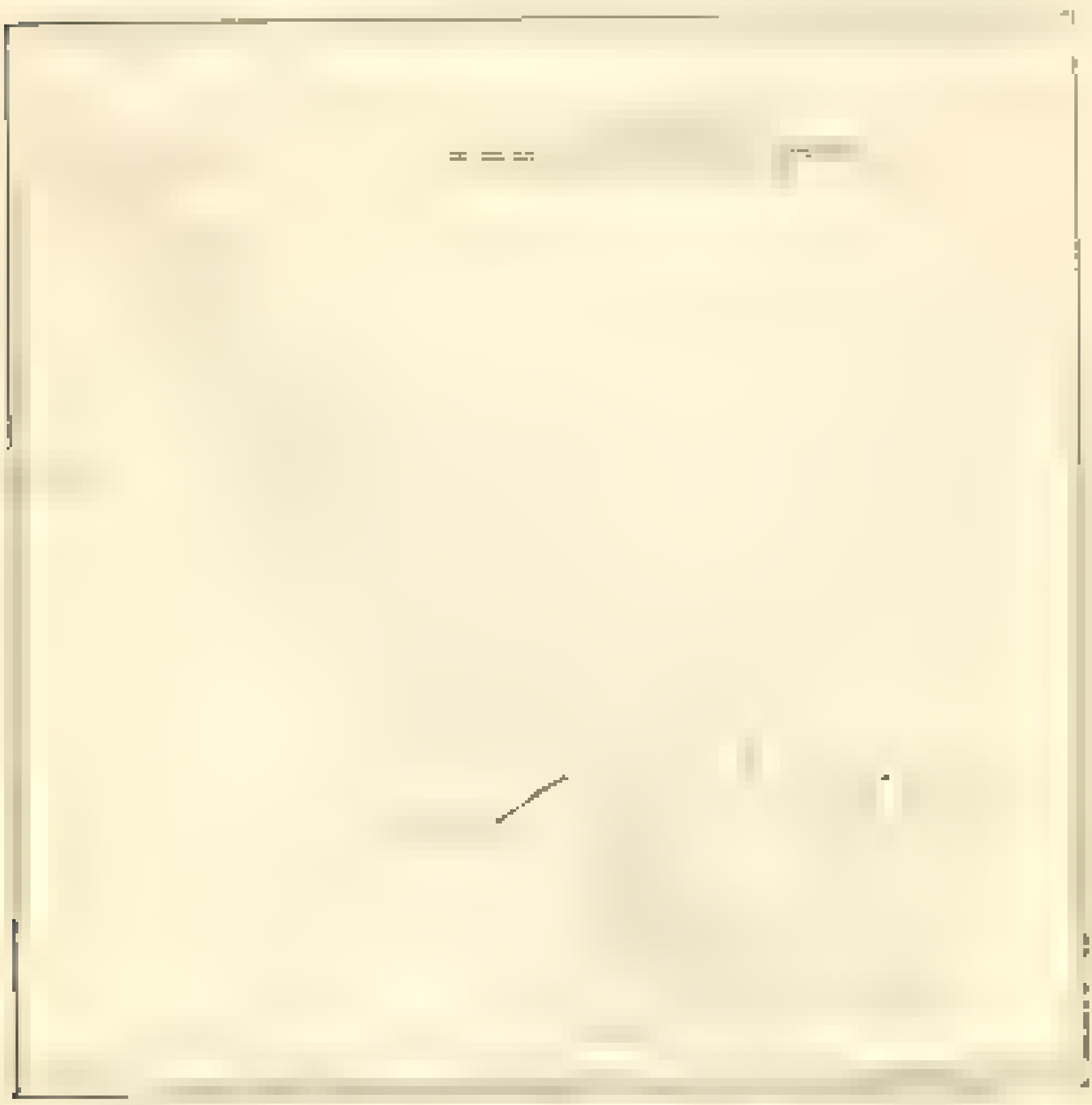
The fieldwork was executed during the summer of 1882.

* An account of their work appears in Nat. Geog. Mag., vol. iv, 1892, pp. 177-197.

The party was carried to the working ground by the Coast Survey Steamer *Humboldt*, in command of Captain Harber, who personally took great interest in the work and facilitated its successful performance very much, taking a very important part, in fact, in the determination of the difference of longitude between Sitka and the astronomical station at Yakutat bay. In the absence of telegraphic connection with any of these points, a series of chronometric journeys was made between Tacoma, which is near one of the telegraph longitude stations of the great system of the United States Coast and Geodetic Survey, and Sitka, which has been fixed as the base of the longitude work throughout the territory of Alaska.

Contemporaneously a series of journeys was made between Sitka and the astronomical station at Yakutat bay by the Coast Survey Steamer *Humboldt*, and by these two loops the longitude of the stations was connected with that of the telegraphic system of the United States. Time observations at Tacoma and the comparison of chronometers at that point were under the direction of assistant J. F. Pratt. Six complete chronometer tours from Tacoma to Sitka and return were made on board of the Steamer *Queen*, the chronometers being in charge of Mr. T. D. Davidson, of San Francisco; this link having also been taken in by the *Humboldt* chronometers on her way to and from the fleet, seven complete journeys are available between Tacoma and Sitka. Six complete journeys between Sitka and the astronomical station at Yakutat bay were made. An astronomical station was established at Sitka under the direction of sub-assistant Fremont Morse, who had charge of time-observations and the comparison of both sets of chronometers on reaching that point. Seven chronometers made the journeys between Tacoma and Sitka, and the same number between Sitka and Yakutat bay. The astronomical station at the latter place was in charge of assistant J. Henry Turner. The connection of this station telegraphically with the summit of mount Saint Elias was under the direction of assistant J. E. McGrath. The astronomical station was on the southern side of Yakutat bay, and the monument base line from which the triangulation was developed was on the northern side. The length of this line was a little less than 2,000 metres, or about four and a half miles. The scheme of triangulation is shown on the accompanying sketch (figure 2). The latitude of the astronomical station was determined by

[illegible]



[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

The type and generic position theorem

[illegible]

[illegible]

Harvard University [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Northwest Passage [illegible]

[illegible] Mr. Baker [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] the North American continent [illegible] large part of what is [illegible] Atlantic [illegible] from [illegible] Gulf of Mexico [illegible] to the West Indian [illegible] western [illegible] present Rocky Mountains and Sierra Nevada [illegible]. The [illegible] formed of various [illegible] Park and [illegible] portions of the Rocky Mountain region.

[illegible] waters of the [illegible] the western [illegible] of the Atlantic [illegible] rock [illegible] brooks and rivers [illegible] Alabama [illegible] After [illegible] the water [illegible]

[illegible]

[illegible]

[illegible] Tenth [illegible]

[illegible]

[illegible]

[illegible]	
[illegible]	[illegible]
[illegible]	[illegible], England [illegible]
	[illegible]
[illegible]	[illegible], France
[illegible]	[illegible]
	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible], United States
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible], Russia
[illegible]	[illegible], Italy
[illegible]	[illegible], United States
[illegible]	[illegible]
[illegible]	[illegible], United States
[illegible]	[illegible], United States
[illegible]	[illegible], England
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible], New South Wales
[illegible]	[illegible]
	[illegible]
[illegible]	[illegible]
[illegible]	[illegible], England
[illegible]	[illegible], Germany
	[illegible], Germany
[illegible]	[illegible], England [illegible]
	[illegible], England
[illegible]	[illegible], Germany
[illegible]	[illegible], Germany
[illegible]	[illegible]
[illegible]	[illegible]

[illegible]
[illegible]

List of the most populous cities of the world. [illegible]

Rank	Founding year	City	Population
[illegible]	[illegible]	Stockholm, Sweden [illegible]	
[illegible]	[illegible]	Odessa, Russia [illegible]	
	[illegible]	Hyderabad, India	
[illegible]	[illegible]	San Francisco, United States	
	[illegible]	[illegible], Spain	
[illegible]	[illegible]	[illegible], United States	
[illegible]	[illegible]	Milan, Italy	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	Buffalo, United States	
[illegible]	[illegible]	Dresden, Germany	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	Barcelona, Spain	
[illegible]	[illegible]	Cleveland, United States	
[illegible]	[illegible]	[illegible]	
[illegible]	[illegible]	Belfast, Ireland	
[illegible]	[illegible]	Bordeaux, France	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible], United States	[illegible]
[illegible]	[illegible]	Washington, United States	[illegible]
[illegible]	[illegible]	Turin, Italy	[illegible]
[illegible]	[illegible]	Antwerp, Belgium	[illegible]
[illegible]	[illegible]	[illegible], India	[illegible]
	[illegible]	Bucharest, Roumania	[illegible]
	[illegible]	Bristol, England	[illegible]
	[illegible]	Hong Kong, China	[illegible]
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	Detroit, United States	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	Magdeburg, Germany	
	[illegible]	[illegible]	
	[illegible]	Newcastle, England	
	[illegible]	[illegible]	
	[illegible]	[illegible], Hungary	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible]	
	[illegible]	[illegible], India	[illegible]

[illegible]

In view of the progressive, ennobling influence exercised by great cities upon the progress and welfare of the world, it is interesting to consider that more than one-half of the cities here [illegible] are either populated by English-speaking races or are under their control. Of [illegible] cities two are in Australia, two in India, one in China, two in Egypt, [illegible] in England, ten in [illegible], two in Ireland, two in Scotland, one in Singapore, and seventeen in the United States.

It is not the purpose of this sketch to investigate the causes which particularly favor the enormous growth of some great modern cities, for these causes must be very complex and local, and [illegible]. It is evident, however, at a glance that the elements of cheap transportation and a moderately temperate climate are to be found [illegible], though they are not the product of these causes. As some one has very wisely remarked, "it is [illegible] that great rivers run by great cities," and it is to be noted that few cities are found where there is not cheap water transportation. By far the greater number of large cities are situated [illegible] in the parts of Europe and America where [illegible] general [illegible] there is one city of 100,000 inhabitants for about every 2,000,000 of population. In [illegible] there is only one [illegible]

* With but few exceptions the great cities of the world are the product of the age, as is indicated by the fact that at the beginning of this century [illegible] had [illegible] cities of one hundred thousand inhabitants, whereas it has now twenty-[illegible]. England had [illegible] only; now it has twenty-four.

1 Volcanic Ash and Lapilli Bed
2 Original Soil
3 Present Ground Level
4 Base of Crater Filled with Ash of Volcanic Ash and Lapilli Bed
5 Soil Formed by the Decay of Old Fern Tree

longest [illegible] since the cinder cone are of less than 200 years. [illegible] the eruption [illegible] cinder cone [illegible] have occurred [illegible] more than 200 years ago.

On the whole, it would seem probable, therefore, that our youngest volcano south of Alaska is not the cinder cone ten miles northeast of Lassen peak as once supposed, but is more likely to prove to be Mount Baker, in Washington.